

INSTRUCTIONS  
FOR THE USE  
AND CARE OF  
**Portable  
Potentiometer**

*Type No. 44228*

OLD - 7569 P.  
PYE.

C21-743 2472

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## 1. GENERAL

The Portable Potentiometer, Type 44228, is intended for the measurement of d.c. potentials up to 101mV, or, by using a voltage divider or current shunts, for extended measurements up to 500V and 10A. The accuracy is  $\pm 0.1\%$  of reading or  $5\mu\text{V}$ , whichever is the greater. The instrument contains its own reference standard cell and supply batteries for the potentiometer and for a built-in potential source which will deliver voltages up to 100mV.

A combination of robustness and accuracy makes this potentiometer the ideal tool for checking thermocouples and auxiliary temperature measuring equipment or for any other jobs in the factory where accurate measurement of direct current or voltage is required.

A built-in taut suspension galvanometer provides adequate sensitivity for most measurements, but in exceptional circumstances, when extra discrimination is needed, it can readily be replaced by a reflecting galvanometer. If the galvanometer is damaged it can be removed and replaced without opening up the instrument and without unsoldering any wires.

## 2. OPERATING INSTRUCTIONS

### 2.1. Preparations for use

At least 10 minutes before measurements are made, set the function switch (6) (see illustration) to any position other than 'OFF.' This will give the battery time in which to become stable, and will ensure that drift does not occur during measurement. If the potentiometer is a new one being set up for the first time the batteries will be supplied in a separate container and must be mounted into the instrument as described under Section 7 'BATTERIES'. Set the clamp (2) to 'FREE' and, if necessary, turn the zero adjuster (1) until the pointer rests over the zero line marked 'O' on the galvanometer scale.

### 2.2. Standardisation

Press the standardising key (14) and turn the standardising rheostat control (12) until the galvanometer pointer is restored to zero. If the galvanometer deflection is violent do not keep the key pressed as this will damage the reference cell. In such cases press the key at intervals whilst restoring galvanometer balance, and if balance cannot be obtained over the travel of the standardising rheostat, refer to SECTION 7 'BATTERIES'. The sensitivity of the galvanometer when standardising is such that very accurate balancing is unnecessary. One division out of balance on the galvanometer scale represents an error of only 0.03% of measurement.

### 2.3. Measuring potentials up to 101mV

Having standardised the potentiometer, connect the potential to be measured to either pair of the terminals marked 1 and 2, (7) and (8) on the illustration. Set the function switch (6) appropriately, depending upon which terminals are used. If the potential to be measured is known approximately, set the measuring dials (10) and (11) to read this value. Press the 'TEST' key (13) and turn first the coarse (11), then the fine (10) potential dials until galvanometer balance is restored. If the galvanometer deflection is to the right, increase the reading of the potential dials, and if to the left, reduce their values. Failure to move the pointer from the right hand end of the scale indicates a test potential greater than 101mV. Failure to move the pointer from the left hand end of the scale indicates reversed polarity at the test terminals. Occasionally it is advisable to recheck the standardisation to make sure that battery drift has not taken place. To do this, press the 'STD' key (14) and, if necessary, restore the galvanometer to zero by turning the standardising rheostat (12). It is not necessary to disconnect the potential being measured or to change the setting of the potential dials whilst this is being done, but if any alteration of the standardising current is necessary a new balance on the potential dials must be made. After final balance, the potential is read as the sum of the two potential dials (11) and (10) and is expressed in millivolts.

## 3. CHECKING THERMOCOUPLES

### 3.1. Measuring the temperature of a thermocouple

To measure temperature with a thermocouple it is necessary to measure the millivolts produced by the thermocouple and to convert this to a temperature by using a table of Thermo-Electric Characteristics. A book is supplied with each potentiometer and in it are the temperature-millivolt characteristics for four types of thermocouples. Platinum 13% Rhodium V Platinum, Ni/Cr V Ni Al, Iron V Constantan and Copper V Constantan. The constants shown in the book are also given in British Standards BS.1826, BS.1827, BS.1828 and BS.1829.

Place the thermocouple in a furnace or bath to the correct depth and connect the thermocouple leads to test terminals 1 or 2 on the potentiometer. Standardise the potentiometer and measure the millivolts produced by the thermocouple using the method previously described. The millivolt reading on the potentiometer is then converted to the equivalent temperature in the manner shown in the example.

Allowance must be made for the temperature of the cold junction, the value of which is obtained from the reading of the thermometer mounted on the potentiometer panel with its bulb adjacent to the test terminals. If the thermocouple has its own cold junction the temperature

indicated at that junction should be used in preference to that at the test terminals.

#### EXAMPLE

Iron V Constantan Thermocouple to BS.1829

Reading on Potentiometer	46.82mV
Millivolts corresponding to cold junction temperature (say 20°C)	1.02mV
	<hr/>
	47.84mV

From the table of constants for these thermocouples the temperature is found to be 836°C.

### 3.2. Checking a thermocouple against a standard thermocouple

Place a standard thermocouple, the characteristics of which are known, in a furnace or bath alongside the one to be tested and with the same depth of immersion. Connect the leads from one thermocouple to the test terminals 1 and those from the other thermocouple to test terminals 2. Standardise the potentiometer and measure the millivolts from the standard and test thermocouples in turn, setting the function switch (6) to the appropriate position for each measurement. The millivolt outputs from the two thermocouples may then be compared or the differences may be converted to temperature using the tables of Thermo Electric Characteristics.

### 3.3. Checking a thermo-electric indicator against a standard thermocouple

Place a standard thermocouple in the furnace or bath alongside the thermocouple used with the indicator and with the same depth of immersion. Standardise the potentiometer and connect the leads from the two thermocouples to test terminals 1 and 2 respectively. Determine the temperature of the standard thermocouple and compare this with the temperature indicated by the instrument on test.

## 4. CHECKING RECORDERS, INDICATORS AND CONTROLLERS

### 4.1. Potentiometric types

Provided an instrument in this class has no attenuator or other d.c. path across its input terminals, it will not load the checking instrument. In these circumstances the potentiometer may be used with the function switch (6) set to mV when the potential appearing across the brushes of the dials (10) and (11) may be applied directly to the instrument under test.

Disconnect the input leads from the instrument under test. Controllers having a broken couple device should have the dry cell associated with it disconnected. Connect the input terminals of the instrument to test terminals 2 on the potentiometer; compensating wire should always be used when connecting low range instruments. Refer to the maker's instructions where applicable. Standardise the instrument under test, set the potentiometer function switch (6) to 'mV' and standardise the potentiometer.

Measure the temperature at the cold junction compensating device inside the recorder and subtract the millivolt equivalent of this temperature from the potential necessary to give the required deflection. Set dials (11) and (10) to the calculated value of potential. Switch the instrument under test to 'ON' or 'TEST' according to the maker's instructions and observe the deflection.

Any potentiometric type of recorder, indicator or controller which has a potential divider connected across its input may be tested in the manner described in 4.2.

#### 4.2. Moving coil types

The millivolt supply unit (4) and (5) is a self contained potential source which is connected internally to the terminals 2 when the function switch (6) is set to 'mV SUPPLY'. If a current consuming instrument is connected to these terminals the instrument may be deflected to any point on the scale and the potential applied to produce the deflection can be measured on the potentiometer, thus checking its calibration.

Disconnect the input leads from the instrument to be checked. It is usually necessary to replace the disconnected device with an equivalent resistance which should be connected in series with the potentiometer. If the device is a thermocouple the instrument will now normally read ambient temperature, and there are two methods of allowing for this.

The first is to subtract the millivolt equivalent of the ambient temperature from the millivolts required to give, say, full scale deflection and apply this potential to the instrument on test.

The other method, which can only be used if the scale is marked in °C and not if the scale is marked in °F, is as follows:

Set the instrument to its mechanical zero and apply the full potential for the required deflection, thus eliminating calculations for ambient temperature allowances. (Do not forget to reset the pointer to read ambient temperature after the tests have been completed).

Connect the test terminals 2 to the input terminals of the instrument under test, including, if necessary, the equivalent resistance previously mentioned. Standardise the instrument under test, following the maker's instructions. Set the potentiometer function switch (6) to 'mV SUPPLY' and leave it there throughout the test. Standardise the potentiometer

and turn the 'mV SUPPLY' controls (4) and (5) until the instrument under test reaches the required deflection. Measure the potential giving this deflection using the potentiometer in the usual way.

### 5. MEASURING DIRECT VOLTAGE

5.1. The range of the potentiometer may be extended with the aid of a Volt Ratio Box, Type 44763. This has an output tapping of 100mV and input tappings of 1V, 10V, 100V and 500V giving ratios of 10:1, 100:1, 1000:1 and 5000:1.

The ratio accuracy is  $\pm 0.1\%$  and with a resistance of  $100\Omega/V$  the current consumption is 10mA.

#### 5.2. Method of use

Connect the supply to be measured between 0 and the appropriately marked terminal. The terminal marked 'CONNECT TO EARTH' should be connected to a good earth whenever possible. The terminals on the Volt Ratio Box marked 'POTENTIOMETER 100mV' should be connected to test terminals 1 or 2 on the potentiometer and the function switch set to indicate the pair of terminals chosen. Standardise the potentiometer, switch on the test voltage and measure the potential in the usual way. The value of the voltage under test is then the reading on the potentiometer multiplied by the ratio of voltages used on the Voltage Ratio Box.

#### EXAMPLE

A voltage applied to the 500V terminals gives a reading of 60mV on the potentiometer. This is multiplied by the ratio 5000:1 giving 300V.

### 6. MEASURING DIRECT CURRENT

6.1. The potentiometer may be used for measuring direct current with the aid of a suitable 4 terminal resistor of known value. The following range of Manganin resistors is available for measurement of current up to 10 Amperes with a high order of accuracy. All the resistors tabled are accurate to  $\pm 0.05\%$  of their nominal value at their rated current.

Type	Resistance $\Omega$	Current A	Max. Range with Potentiometer A
43147	0.01	10	0 — 10
43148	0.02	5	0 — 5
43151	0.1	1.5	0 — 1
43149	0.2	1.0	0 — 0.5
43152	1.0	0.5	0 — 0.1
43153	10	0.15	0 — 0.01
43154	100	0.05	0 — 0.001

Shunts for the measurement of larger direct currents are also available.

## 6.2. Method of use

Select a suitable resistor and connect the two larger terminals in series with the supply to be measured. Connect the two smaller terminals marked 'POTENTIAL' to either pair of test terminals on the potentiometer and set the function switch to the appropriate position. Standardise the potentiometer in the usual way, switch on the supply under test and measure the potential across the resistor.

The value of the current flowing is then found by dividing the measured potential in volts by the resistance of the shunt in ohms.

### EXAMPLE

A potential of 75mV (0.075V) is measured using the 0.1Ω resistor. The current flowing is:

$$\frac{0.075V}{0.1\Omega} = 0.75A.$$

## 7. BATTERIES

The battery compartment will be found on the left hand side of the wooden case and access to it is obtained by pressing the push button once, after which the cover may be withdrawn. Two dry cells are needed with a voltage between 1.3 and 1.5 volts. One supplies the current for the potentiometer and the other for the potential source. Although the current drain is only about 5mA, it is essential that the voltage remains steady under load conditions for long periods of time, and for this reason mercury cells, such as Mallory RM42R, are recommended. The two cells should be mounted in their compartments between the spring clips, observing correct polarity as marked on the cells and on the moulding of the compartments. To replace the cover, press the push button once again. New cells should be fitted if frequent standardisation of the potentiometer is necessary and when the output from the potential source becomes unsteady.

If the potentiometer is stored without use for some time it is advisable to remove the batteries from their compartments to avoid the possibility of damage due to corrosion if the batteries deteriorate. To ensure long life from the batteries, the function switch should be turned to 'OFF' when measurements have been completed.

## 8. GALVANOMETER REPLACEMENT

### 8.1. Pointer galvanometer

The taut suspension galvanometer fitted to this potentiometer is Type 41157/6; it has a resistance of 20 ohms. If it becomes damaged it can readily be changed for another galvanometer of the same type whilst

it is being repaired. Clamp the movement and unscrew the barrel-nut below the galvanometer on the bottom of the wooden case. Undo the two connecting links at the galvanometer terminals and lift the instrument from the panel. When a new galvanometer has been fitted, set the pointer to zero ('0' on the scale) before resuming measurements.

### 8.2. Using an external galvanometer

An external galvanometer may be used without removing the one mounted in the potentiometer. All that is necessary is to remove the two connecting links from the galvanometer in the instrument and connect the external galvanometer to the two terminals on the panel. Cambridge Spot Galvanometer, Type 41154/1, has about ten times the sensitivity of the galvanometer normally fitted to the potentiometer.

## 9. MAINTENANCE

### 9.1. Contacts

Normally, very little maintenance will be needed to keep the potentiometer in good working condition, but after continuous use in a corrosive atmosphere, some cleaning of the contacts may be necessary. The need for cleaning is usually indicated by erratic movement of the galvanometer pointer whilst balancing, or by the galvanometer pointer remaining on zero regardless of the position of the potentiometer dials.

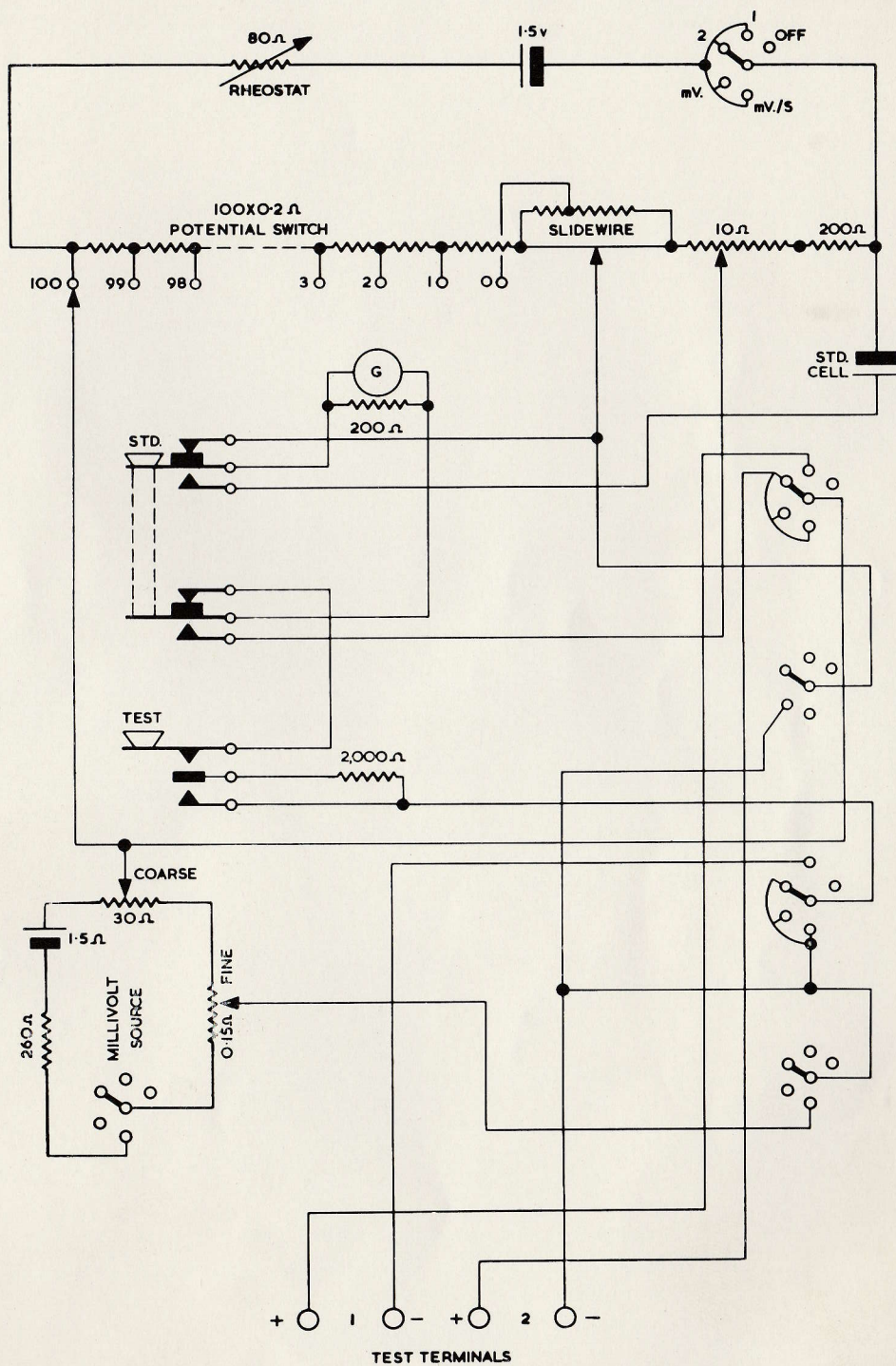
Clamp the galvanometer, remove the cover from the battery compartment and the five barrel nuts from the bottom of the wooden box. Lift the panel and invert it so that the inside of the instrument is exposed. The contacts on the Function Switch cannot be cleaned and the small variable resistance mounted beneath the Coarse Potential dial must on no account be touched as any change in the position of its brush will cause the potentiometer to give wrong readings. The contacts on the Coarse Potential switch and the track on the Fine Potential dial, the Standardising rheostat and the Millivolt Supply coarse and fine rheostats should be wiped with a cloth moistened with trichlorethylene or carbon tetrachloride. After cleaning, a small amount of Contact Lubricant should be spread on the switch segments and on the rheostat tracks. Use oil sparingly as excessive oiling will only serve to collect dust and will do more harm than good. On no account should the brushes be removed from any of the controls whilst carrying out cleaning operations. If the contacts of the two press keys give trouble, a piece of smooth writing paper inserted between the contacts and moved backward and forward with the key pressed down will usually be sufficient, but in extreme cases it may be necessary to lightly scrape the contact points.

## 9.2. Replacement of standard cell

If it is impossible to standardise the potentiometer and replacing the battery does not cure the fault, the standard cell should be changed. The cell used in this potentiometer is a saturated cadmium standard cell, Type 44115; it is situated between the function switch and the fine potential dial. The two soldered joints must be released from the tags on the cell and the screw on the fixing bracket slackened. The cell may now be lifted out and a new one fitted in its place. When connecting the new cell be sure that the brown wire is soldered to the tag with a red spot and that the green wire together with the copper bus bar from the adjacent coil are soldered to the other tag. Take care not to heat the cell by prolonged application of the soldering iron to the tags.

## LIST OF SPARE PARTS AND ACCESSORIES

Standard Cell	Type 44115
Thermometer	B43
Mallory Battery RM42R	B2071
Galvanometer	Type 41157/6
Terminal Head	E62
Small Bottle Contact Lubricant	SA358
Volt Ratio Box for ranges up to 500V	Type 44763
Resistor to give range of 10A	Type 43147
„ „ „ „ „ 5A	Type 43148
„ „ „ „ „ 1A	Type 43151
„ „ „ „ „ 0.5A	Type 43149
„ „ „ „ „ 0.1A	Type 43152
„ „ „ „ „ 0.01A	Type 43153
„ „ „ „ „ 0.01A	Type 43153
„ „ „ „ „ 0.001A	Type 43154
Spot Galvanometer	
Mains Operated	Type 41154/1
Battery Operated	Type 41153/1



- 1 GALVANOMETER ZERO ADJUSTER
- 2 GALVANOMETER MOVEMENT CLAMP
- 3 GALVANOMETER CONNECTING LINKS
- 4 MILLIVOLT SUPPLY - COARSE RHEOSTAT
- 5 MILLIVOLT SUPPLY - FINE RHEOSTAT
- 6 POTENTIOMETER FUNCTION SWITCH
- 7 TEST TERMINALS - 1
- 8 TEST TERMINALS - 2
- 9 THERMOMETER
- 10 FINE POTENTIAL DIAL
- 11 COARSE POTENTIAL DIAL
- 12 STANDARDISING RHEOSTAT
- 13 TEST KEY
- 14 STANDARDISING KEY
- 15 BATTERY COMPARTMENT

